Canadian Aviation Safety Board

Bureau canadien de la sécurité aérienne

Canada

THE CARRIAGE AND USE OF OVERWATER LIFE-SUPPORT EQUIPMENT IN CANADA

Safety Study by the
Canadian Aviation Safety Board

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1.0 INTRODUCTION

1.1 Background

Each year in Canada accidents occur in which aircraft are ditched or inadvertently contact water and in which the crew and passengers are required to abandon the aircraft. In most of these occurrences, life-saving equipment is not used, either because it is not carried on board the aircraft or because there is insufficient time to retrieve and don it.

As is the case with most safety-related issues, the carriage and use of life-saving equipment is governed by regulations designed to suit a particular set of circumstances. The accident experience indicates that the applicable regulations often do not reflect the reality of water contact situations. For example, twin-engined aircraft, which are able to maintain flight with the critical engine failed, are not required to carry life-jackets unless they are being operated in excess of 50 nautical miles from shore. However, the Canadian accident record shows that all the water contact accidents from 1976 to 1985 involving multi-engined aircraft occurred within this distance.

On two recent occasions, both involving twin-engined commercial aircraft, lives were undoubtedly saved because life-saving equipment was carried beyond that required by regulation (CASB Occurrence Investigation Reports W40062 and Ø70004).

Concern for the safety of overwater flight has been long-standing. The Board has previously identified several safety deficiencies pertaining to the design standards, maintenance and inspection procedures for life-jackets, immersions suits, and life-rafts (see CASB Recommendations 86-28 to 86-36). Notwithstanding the generally positive response by Transport Canada to these Recommendations, the Board has continuing reason to believe that regulatory inadequacies continue to aggravate the severity of overwater aviation occurrences.

1.2 Aim

The aim of this study is to examine the safety issues relating to the carriage and use of overwater life-saving equipment in aircraft in Canada particularly in the light of the Canadian accident experience.

1.3 Scope

This study examined Canadian and International Civil Aviation Organization (ICAO) accident data to determine if the various regulations governing the carriage, stowage, and use of overwater life-support equipment adequately related to the accident experience. Data are presented by aircraft category, both fixed and rotary wing. Due to the particular nature of floatplane operations, floatplane accidents were examined separately. For the purposes of this study, overwater life-support equipment includes life-jackets, life-rafts, slide/life-rafts, and flotation devices. No consideration is given in this study to such other overwater life-support equipment as immersion suits, signalling devices, medical and ration kits, and crew training.

2.0 ACCIDENT DATA

2.1 General

Data were extracted from the Canadian Accident/Incident Data base (CAIDS) and the ICAO data base under the categories of "ditching" and inadvertent water impact or "collision with water." Floatplane accidents seldom fall into either category and were therefore extracted separately from the data base. Ditching, although not defined in regulations, usually means a planned event in which the flight crew attempts an emergency landing on water. In contrast to an inadvertent water impact, in which there is no time for passenger or crew preparation, ditchings allow some time for briefing, donning life-preservers, etc. Although ditchings tend to be more survivable and hence provide better opportunity for the use of survival equipment, many accidents listed as "collision with water" are also survivable and consequently warrant consideration when evaluating the need for such equipment.

2.2 Ditching Accidents

2.2.1 Canada

There were 35 reported ditchings of land planes in Canada between 1976 and 1987, resulting in nine fatalities and three serious injuries. Seven of these occurrences involved twin-engined aircraft, none of which was in the transport category (over 5 700 kilograms maximum take-off weight). Six of the 35 aircraft which ditched were engaged in en route overwater flight, while 18 were situations in which the pilot deliberately elected to force-land in the water rather than on the inhospitable surrounding terrain. None was more than 50 nautical miles from land. All but four were the result of a loss of engine power, usually caused by fuel starvation or fuel contamination. Of the multi-engine ditchings, four were the result of double-engine failure while three were caused by failure of one engine (See Table 1).

During the same period (1976-1987) 25 helicopter ditchings were recorded in Canada, none of which resulted in fatalities. Of this total, 13 were caused by engine failure, three by mechanical failure, two by striking wires, and seven by loss of control. Three twin-engined helicopters were ditched, one as a result of single-engine failure, one as a result of loss of control, and one was caused by a mechnical failure (loss

of transmission oil). Many of these occurrences took place in small ponds or lakes, often during fire-fighting operations. This, plus the relatively gentle water entry of a helicopter in autorotation likely accounts for the absence of fatalities (See Table 2).

2.2.2 ICAO

The ICAO data base (excluding Canadian data) recorded 118 airplane ditchings from 1976-1987. The majority of these (113) were twin-engined aircraft (ICAO only records occurrences involving aircraft over 2 250 kilograms). Sixteen were transport-category aircraft, although none involved a large passenger-carrying jet.

Just over 50 per cent (59) of the twin-engined aircraft which ditched experienced a double-engine failure while 30 per cent (36) were aircraft unable to maintain flight after the failure of one engine (See Table 3).

ICAO also recorded 54 ditchings of twin-engined helicopters between 1976 and 1986. Engine failure was the cause of 20 per cent (11) of these with the remainder almost equally divided between some type of mechanical failure and loss of control or collision in flight (See Table 4).

2.3 Inadvertent Water Impacts

The CAIDS data base recorded 101 inadvertent water impact accidents from 1976-1986, resulting in 102 fatalities. These accidents are by their nature more catastrophic than ditchings and have a higher fatality rate (48 per cent). The majority of these accidents were caused by a loss of control in flight at low level often after take-off from an airstrip near water.

2.4 Floatplanes and Amphibious Airplanes

Between 1976 and 1986, there were 1,022 floatplane and amphibian accidents in Canada. One hundred and ninety-three of these were fatal, resulting in a total of 395 fatalities. Approximately 50 per cent of the accidents involved contact with the water, usually on take-off, landing, or taxiing. It is difficult to determine the role that overwater life-support equipment might have played in these occurrences. In many of the survivable fatal accidents, the occupants did not get out of the aircraft, either as a result of impact injuries or confusion and panic. In these cases, a life-preserver would not have helped. There were eight occurrences in

which the occupants exited the aircraft successfully but drowned attempting to swim to shore; in these cases, wearing a life-jacket would likely have helped.

There is evidence that occupants sometimes drowned while attempting to reach life-jackets stowed in the rear of the cabin or under seats. Often the aircraft became inverted in the water, suspended by the floats. The occupants then swam to the surface whereupon one would dive back to the aircraft to retrieve the life-jackets. An examination of the accident data failed to identify a single instance in which the occupants donned life-jackets after the accident and prior to evacuating the aircraft.

TABLES

TABLE 1

FIXED-WING DITCHING ACCIDENTS - CANADA - 1976-1987

Type	Total	Fatalities	Single-Engine Failure	Double-Engine Failure	Overwater Flight	Deliberate Ditching
Single Engined	28	7	24	N/A	3	14
Twin Engined	7	2	3	4	3	4
TOTAL	35	9	27	4	6	18

TABLE 2

ROTARY-WING DITCHING ACCIDENTS - CANADA - 1976-1987

Type	Total	Fatalities	Engine Failure	Mechanical Failure	Wire Strike	Loss of Control
Single Engined	22	0	12	2	2	6
Twin Engined	3	0	1	1	0	1
TOTAL	25	0	13	3	2	7

TABLE 3

DITCHING CAUSES - ICAO - 1976-1986
TWIN-ENGINED FIXED-WING AIRCRAFT

CAUSE	NUMBER
Single-Engine Failure	36
Double-Engine Failure	59
Fire in Flight	5
Door Open in Flight	1
Collision	2
Propeller Failure	1
Avionics Failure	1
Unknown	8
TOTAL	113

TABLE 4

DITCHING CAUSES - ICAO - 1976-1986
TWIN-ENGINED HELICOPTERS

CAUSE	NUMBER
Engine Failure	11
Collision (Ground or Air)	12
Tail Rotor Failure	8
Loss of Control	6
Flight Control Failure	2
Engine Disintegration	2
Main Rotor Failure	7
Other/Unknown	3
Missing	1
Airframe Failure	1
Injuries in Flight	1
TOTAL	54

3.0 ASSOCIATED RESEARCH

3.1 U.S. Federal Aviation Administration (FAA) "Study on Transport Airplane Unplanned Water Contact" (1)

This study provided for an identification of accident scenarios and associated occupant risks and survival equipment needs, relating to the inadvertent or unplanned water contact of transport-category airplanes.

The data base used in this study was compiled from several sources and identified 11 passenger-carrying jet transport accidents worldwide from 1959-1979 in which water played a significant part in causing casualties or injuries. Of these accidents, only one, a DC-9 which ran out of fuel and ditched near St. Croix, Virgin Islands, in May 1970, was a planned emergency landing. The remainder were inadvertent water impacts, five of which occurred during the landing phase, four on the approach phase and two on take-off. None was more than 50 miles from shore. Of a total of 894 persons on board these aircraft, 218 lost their lives.

Conclusions reached by the FAA which are germane to this study are as follows:

a. Planned ditchings of passenger transport-category aircraft are extremely rare.

b. Inadvertent water impact accidents, though more common than ditchings, are also infrequent. Those that are survivable usually involve severe aircraft damage, occupant injuries, rapid flooding of the cabin, and sinking of the aircraft within a short time.

c. Most survivable inadvertent water impacts have occurred closer to shore than 50 nautical miles, near an airport, on approach or departure.

(1) DOT/FAA/CT-84/3 - Study on Transport Airplane Unplanned Water Contact. February 1984

d. There are at least 179 fully certificated airports in the United States with significant bodies of water within five miles (2); flights that involve use of these airports present a risk of inadvertent water impact, even if the flight is not classified as "extended overwater" or "any overwater."

e. Flotation seat cushions alone are insufficient as water-survival equipment on any flight being operated under parts 121, 125, or 135; however they are useful supplements to other equipment (life-preservers, slide/raft combinations, modified evacuation slides).

3.2 U.S. National Transportation Safety Board Study: "Air Carrier Overwater Emergency Equipment and Procedures" (3)

This study focused on the design and availability of life-support equipment and arrived at similar conclusions to the FAA study (Para 3.1).

The abstract from this study is repeated below:

> "The chances of surviving air carrier accidents into water would be increased if Federal Aviation Administration (FAA) emergency procedures and FAA-approved survival equipment were improved. Current procedures and equipment are designed on the assumption that air carrier water contact accidents are primarily ditchings, a water accident characterized by at least some preparation time and relatively little aircraft damage. In fact, a review of air carrier water contact accidents between 1959 and 1984 shows that such accidents are typically inadvertent, with no preparation time, substantial aircraft damage, and a high chance of occupant injury. Often the cabin floods quickly, followed by sinking of the aircraft within minutes.

(2) A 1982 Transport Canada study on Water Rescue Capability identified 37 Transport Canada owned and operated airports providing Airport Emergency Services which were within 15 kilometres of a significant body of water or had a "Final Approach Fix" within 15 kilometres of a significant body of water. There are many airports, such as Toronto Island and Kingston, which do not meet the selection criteria but present similar risks.

(3) U.S. National Transportation Safety Board Study "Air Carrier Overwater Emergency Equipment and Procedures". 1985

Typically, these accidents do not occur on "extended overwater flight" (the type of operation to which most FAA water survival regulations currently apply) but close to an airport, during approach or departure.

The Board [NTSB] recommended the FAA require both life-preservers and flotation seat cushions on all air carrier flights, and asked for improvements in life-preserver design, packaging, accessibility, and ease of donning. Other recommendations dealt with emergency evacuation slides, liferafts, flotation devices for infants, crew post-crash survival training, and water rescue plans at airports near water."

4.0 REGULATIONS

4.1 General

The Air Navigation Order Respecting Life-saving Equipment for Aircraft Operating Over Water (ANO Series II No. 8 - See Annex A) governs the standards, maintenance, and use of life-saving equipment in Canada. Some certification requirements are contained in the Federal Aviation Regulations (FAR) of the United States which have been incorporated into the Canadian Airworthiness Manual (TP6197E). This section contains a summary of the pertinent Canadian regulations, followed by a review of the equivalent regulations of the United States and the United Kingdom.

4.2 Canadian Regulations

4.2.1 Life-Jackets

1) Carriage

Schedule I of ANO Series II No. 8 requires that one life-jacket for each person aboard be carried by:

(a) Single-engined aircraft or multi-engined aircraft unable to maintain flight with the critical engine failed when operating beyond gliding distance of land or taking off or landing on water.

(b) Multi-engined aircraft able to maintain flight with the critical engine failed and turbo-jet aircraft with three or more engines, capable of flying to a suitable aerodome with two engines inoperative, when operating more than 50 nautical miles from shore or landing or taking off from water.

2) Stowage

Paragraph 5 of ANO Series II No. 8 requires that every life-jacket required to be carried on board an aircraft shall be stowed in such a manner as to be easily accessible to the person for whose use it is intended. The terminology used in the Airworthiness Manual is slightly different; Para 523.1411 states that the stowage for safety equipment must be "directly accessible" and para 523.1415 uses the term "readily available" to crew and passengers. Both of these sections apply to the certification of small aircraft.

Transport aircraft, (over 5 700 kilograms), which are certified under para 525.1411 of the Airworthiness Manual in respect to safety equipment, require that each life-jacket must be within easy reach of each seated occupant.

4.2.2 Life-Rafts

Schedule I of ANO Series II No. 8 requires that life-rafts of sufficient capacity to accommodate all persons aboard be carried by:

(a) Single-engined or multi-engined aircraft unable to maintain flight with the critical engine failed operating more than 50 nautical miles from shore.

(b) Multi-engined aircraft able to maintain flight with the critical engine failed operating more than 300 nautical miles from shore; and

(c) Turbo-jet aircraft with three or more engines, capable of continuing flight to a suitable aerodrome with two engines inoperative, operating 400 miles or two hours cruising time, whichever is the lesser from shore.

In addition, the Airworthiness Manual para (525.1415(1)) which governs the certification of transport-category aircraft with respect to ditching equipment, states that:

(1) Unless excess rafts of enough capacity are provided, the buoyancy and seating capacity beyond the rated capacity of the rafts must accommodate all occupants of the airplane in the event of a loss of one raft of the largest rated capacity.

Some large passenger-carrying aircraft types are equipped with an evacuation slide/life-raft combination which meets the requirements for life-rafts specified in ANO Series II, No. 8.

4.2.3 Passenger Briefing

Passenger briefings on emergency equipment are required for operations governed by ANO Series VII No. 3 (Air Carriers using Small Aeroplanes). However, ANO Series II No. 8, which applies to all aircraft, requires that passengers be briefed on the overwater location and method of use of the life-saving equipment only before the aircraft is flown en route over water. Thus, there is no legal requirement for the pilot of a privately

operated floatplane to brief passengers prior to take-off, since the take-off phase of flight is generally considered to be distinct from the "en route" phase. Considering that most such accidents occur during the take-off, approach, or landing phases of flight, the rationale for the emphasis on "en route" is not understood.

4.3 U.S. Regulations

U.S. FARs governing survival equipment for overwater operations are summarized below:

4.3.1 Part 91 - Subpart D - General Operating Rules for Large and Turbine-Powered Multi-Engined Airplanes

Large and turbine-powered multi-engined airplanes on non-commercial service operating more than 50 nautical miles from shore require a life-preserver or an approved flotation device for each occupant. If the airplane is operated more than 30 minutes flying time or 100 nautical miles from shore, a life-preserver for each occupant and life-rafts sufficient to accommodate the occupants of the airplane are required.

4.3.2 Part 121 - Air Carriers and Commercial Operation of Large Aircraft

This part requires that aircraft operated more than 50 nautical miles offshore be equipped with life-preservers for each occupant and life-rafts sufficient for all occupants even in the event of a loss of the largest raft.

Aircraft operated in any overwater operation must carry either life-preservers or approved flotation means for each occupant.

4.3.3 Part 135 - Air Taxi Operators and Commercial Operators

This part is similar to Part 121 in that flight beyond 50 nautical miles of shore requires life-preservers and life-rafts but does not include the stipulation that extra life-rafts be carried.

4.3.4 Part 127 - Scheduled Air Carriers With Helicopters

This part requires that single-engined helicopters be equipped with flotation devices (pop-out floats) and that life-preservers be carried for each occupant before being operated overwater beyond gliding distance of land.

4.4 United Kingdom Regulations

4.4.1 Aeroplanes

Air Navigation Order Schedule 5 - Aircraft Equipment requires that any aeroplane flying for the purpose of public transport meet the following conditions:

a) Life-jackets are required for all occupants when flying beyond gliding distance from land or on all flights on which in the event of an emergency occurring during take-off or landing at the intended destination or any likely alternate destination it is reasonably possible that the aeroplane would be forced to land onto water; and

b) Life-jackets and life-rafts sufficient for all persons on board are required when flying over 400 nautical miles or 90 minutes flying time from a suitable aerodrome in the case of aircraft of certain performance criteria (essentially aircraft able to sustain flight with one or more engine inoperative) or 30 minutes flying time in the case of all other aircraft.

4.4.2 Helicopters

Helicopters operated in the United Kingdom for the purpose of public transport must meet the following criteria:

a) Helicopters classed as performance group A2 or B (essentially single-engined and twin-engined helicopters unable to maintain flight on one engine) operating beyond autorotational gliding distance from land suitable for an emergency landing must carry a life-jacket for all persons aboard.

b) Helicopters classed as performance group A2 when beyond 10 minutes flying time from land must carry life-jackets for all aboard and if carrying 20 or more persons two life-rafts sufficient to accommodate all persons on board.

c) On all flights on which in the event of any emergency occurring during the take-off or during the landing at the intended destination or any likely alternate destination it is reasonably possible that the helicopter would be forced to land on water, a life-jacket for each person aboard must be carried.

5.0 ANALYSIS

5.1 General

This analysis focuses on deficiencies in the carriage and use of overwater life-saving equipment as identified and confirmed by the Canadian and international accident experience. The regulations governing such equipment appear to be based on the probability of the equipment being required, the equipment itself, and the effect of the equipment not being available. These regulations are examined and assessed against the background of the accident record. Some deficiencies were identified based on an assessment of risk.

5.2 Regulations

ANO Series II No. 8 applies to all aircraft in Canada regardless of type of operation. The Air Regulations, however, do prohibit the commercial operation beyond gliding distance from shore of single-engined land planes or multi-engined land planes unable to maintain flight in the event of failure of the critical engine. Transport Canada interprets this regulation as also applying to helicopters.

By comparison, the United Kingdom regulations apply only to aircraft operated for the purpose of "public transport." In the United States, general regulations only apply to large and turbine-powered aircraft. The remaining regulations apply to the various categories governed by the operational FARs.

5.2.1 Single-Engined Land Planes

Single-engined land planes accounted for 80 per cent of the ditching accidents in Canada during the period studied. These aircraft are required to carry life-jackets when operating beyond gliding distance of land and life-rafts when operating beyond 50 nautical miles. With the exception of the five accident aircraft which were engaged in en route overwater flight and which should therefore have been equipped with life-jackets, the remaining 23 were either deliberately landed in water or ditched after a power loss at low level. Fortunately, these accidents took place near shore and only three fatalities resulted. While a prudent pilot might wish to carry life-jackets when overflying wooded or mountainous terrain where lakes represent the only suitable forced landing area, the very low loss of life in this type of accident does not support a mandatory requirement.

Similarly, a pilot contemplating an overwater flight in a single-engined aircraft during times of the year when water temperatures would make survival until rescue arrived doubtful should consider carrying a life-raft. There is, however, little evidence in the accident record to support the need for such a regulatory change for privately operated aircraft.

5.2.2 Twin-Engined Airplanes

Twin-engined airplanes fall into two categories; those able to maintain flight with the critical engine failed and those which are unable. Aircraft from the first category do not require life-jackets unless they are operating beyond 50 nautical miles from shore, while those from the second category require life-jackets when operating beyond gliding distance. In other words, the principal criterion for assessing the probability of water contact is the capability of an airplane to maintain flight after the loss of the critical engine.

Of the seven reported Canadian ditchings of multi-engined airplanes, four were caused by double-engine failures, while three occurred after the failure of one engine. The ICAO statistics indicate that 30 per cent of ditchings of twin-engined airplanes were the result of single-engine failures while just over 50 per cent were caused by the failure of both engines. This means that approximately 70 per cent of ICAO twin-engined airplane ditchings were caused by reasons other than the failure of one engine, which appears to be the basis for the regulatory requirement.

Approximate ditching rates of .18 per 100,000 hours flown for single-engined aircraft and .12 per 100,000 hours for light twin-engined aircraft were calculated from Canadian data. These rates suggest that a twin-engined aircraft has a lower probability of ditching (as one might expect). However, the difference is not considered sufficient to exempt twin-engined aircraft from the carriage of life-jackets when operating over water, particularly when they are carrying fare-paying passengers.

5.2.3 Transport-Category Aircraft

Water contact accidents involving transport-category aircraft are rare world-wide and have been virtually non-existent in Canada. However, there is sufficient data world-wide to conclude that the majority of water contacts are unplanned and take place near airports, certainly within the 50 nautical mile from shore criteria

used to delineate "extended overwater flight" (4). Given current Canadian regulations for transport-category aircraft, a water contact accident could take place in Canada involving a passenger-carrying commercial aircraft which is not equipped with life-jackets.

Fortunately, many Canadian air carriers equip their aircraft with life-jackets as a matter of routine, regardless of whether they are used on extended over-water flight or not. However, there are a number of smaller carriers who routinely fly into airports where the approach, landing, or take-off phases are over water, who do not so equip their aircraft and who are not required to do so by law. One example of such an airport is Toronto Island, where an undershoot or take-off emergency could result in an aircraft contacting the water. In this case, Canadian regulations regarding the carriage of life-jackets would not contribute to the prevention of post-occurrence loss of life.

This safety deficiency was identified following the ditching of a Britten-Norman Islander near Toronto Island in January 1987; consequently, the CASB issued Safety Recommendation CASB 88-21 (Refer to Section 7) which recommended the carriage of life-jackets on all commercial flights operating over water.

5.2.4 Helicopters

Helicopters accounted for 40 per cent of Canadian ditchings, yet comprise only 5 per cent of the total registration of single- and twin-engined aircraft in the private category, or 20 per cent in the commercial category. Many of these ditchings, however, took place in small lakes or ponds, often during fire-fighting operations, and rarely caused fatalities or injuries. Most of the accident helicopters were single engined and were therefore required to carry life-jackets when operating beyond gliding distance of land, although the accident record indicates that life-jackets were rarely carried or used in these accidents.

A greater safety concern is apparent when reviewing twin-engined operations offshore. Helicopters are governed by the same regulations as fixed-wing aircraft in respect to overwater life-saving equipment, yet there is evidence that the reliability of helicopters may be somewhat lower. A review of helicopters airworthiness conducted in the United Kingdom in 1984 concluded that the fatal accident rate for large twin-engined

(4) DOT/FAA/CT-84-3 Feb. 84

helicopters was higher than for comparable fixed-wing aircraft and that there is a significantly higher percentage of accidents due to airworthiness causes for helicopters than for fixed-wing aircraft (5).

An additional factor is that the operational environment experienced in offshore helicopter operations is extremely unforgiving. The higher risks encountered in this type of operation are recognized by Transport Canada and the oil industry as evidenced by survival equipment requirements well beyond those stipulated in ANO Series II No. 8 for helicopters engaged in offshore oil exploration. These additional requirements are detailed in the Operations Specifications and form part of the Operating Certificate issued to the air carrier. Included are such items as life-rafts, the wearing of immersion suits, and the requirement for survival training. These additional equipment requirements undoubtedly aided in the successful ditching and evacuation of a Sikorsky S-61 off Halifax on 20 March 1985. The use of the Operating Certificate to regulate such operations allows Transport Canada flexibility in assessing a company's situation and formulating restrictions which are appropriate; however, without universally applicable regulations, some operations risk being treated differently than others, and regional disparities may arise.

Ideally, differences regarding the degree of risk in any overwater flight, such as distance from land, emergency flotation, water temperature, and availability of rescue services should be assessed with a national consistency and provided for by the regulations.

5.2.5 Floatplanes and Amphibious Aircraft

The 395 fatalities which occurred in float-equipped or amphibious aircraft represent approximately 23 per cent of all aviation fatalities in Canada during the period examined for the study. The fatal accident rate (fatal accidents as a percentage of total accidents) for these aircraft was 18.8 per cent versus 11.2 per cent for all other aircraft.

It was determined that the number of floatplane accidents was roughly proportional to the number of floatplanes; however, as the number of hours flown in float configuration is not known, an accident rate could not be determined. Nevertheless, the significant number of these aircraft having water contact accidents warrants examination.

(5) CAA-CAP491 June 1984

In 57 per cent of the accidents recorded involving these aircraft, the aircraft ended up in the water, usually in an inverted position. A common scenario is for the aircraft to upset on landing or take-off and for the occupants to find themselves in the water with little warning. There is often insufficient time to retrieve and don life-jackets, particularly when they are stowed in the rear of the aircraft. The regulation requiring life-jackets to be "easily accessible" is clearly inadequate in these cases. Requiring life-jackets to be within easy reach of each seated occupant, as is the case with transport-category aircraft, would significantly increase their availability to the users of general aviation aircraft.

Although having life-jackets within reach would be an improvement, the only way to ensure their availability to all occupants during a sudden upset is to wear them during take-off, landing, and while taxiing. It is noted that the Transport Canada Flight Operations Manual requires Transport Canada floatplane pilots to wear life-jackets on any flight where landing or taking off from water is intended. A similar requirement for all floatplanes and amphibians would likely reduce the significantly higher fatality rate associated with float operations.

Operators of floatplanes and amphibians are quick to point out safety-related reasons for not wearing such equipment at all times while on the water. Most of the approved life-jackets on the market are not rugged enough for frequent donning and doffing. They are expensive to maintain and replace, and reliance on possibly unserviceable life-jackets would provide little, if any, increased margin of safety. The basic design also tends to be bulky and is awkward to don or doff in the confined space of general aviation aircraft particularly when adjacent seats are occupied or when wearing winter clothing. Some operators believe that wearing such a bulky jacket could hinder emergency egress, particularly if attempted through a restricted opening such as a window. Given such legitimate operational limitations on the use of the current life-jacket, a different design is required. The design which met the requirements of the aviators of the Second World War apparently is unsuitable for today's operational requirements in general aviation. Revisions to the current Technical Standards Order (TSO) or a new standard may be required to facilitate the availability and wearing of flotation equipment during all operations on water.

In addition to the foregoing limitations on the use of flotation equipment, it is apparent from the accident files that passengers are often not being briefed on the location and operation of life-jackets prior to flight, particularly in privately operated aircraft. While a change in the ANO to require such a briefing would not automatically correct this safety deficiency, it would at least draw the attention of pilots to the requirement.

5.3 Equipment

5.3.1 Evacuation Slide/Life-Raft Combinations

According to ANO Series II No. 8, life-rafts carried on board aircraft must be capable of meeting TSO C12C or C70, dated 11 April 1967. Most wide-bodied aircraft meet the requirement for life-rafts by the use of emergency evacuation slide/raft combinations, thereby accruing major advantages in the ease of deployment and a saving in weight. Unfortunately, ANO Series II No. 8 makes no reference to this combination equipment. The absence of reference to the applicable Technical Standard could result in improvements to slide/raft combinations being required in the United States not being incorporated in Canadian aircraft.

5.3.2 Personal Flotation Devices

The certification requirements for transport-category aircraft include a requirement for an "approved flotation device" for aircraft not certificated for ditching or those not having approved life-preservers. The TSO allows for two types, inflatable and non-inflatable; many carriers meet this requirement by using flotable seat cushions. While a life-jacket is far more effective when worn than hanging onto a cushion, accident experience shows that passengers have had trouble retrieving the life-jacket from under the seat, opening the package, and donning it (6). Flotable seat cushions, on the other hand, are readily available and tend to float free, particularly in accidents which result in a fuselage breakup. In an accident involving a Grumman G-21A in the Virgin Islands in 1978, passengers survived by using ordinary foam seat cushions as a flotation aid (7). The use of flotation seat cushions provides an easily

(6) NTSB-AAR-71-8 (ONA DC-9 near St. Croix, Virgin Islands 02 May 1970)

(7) NTSB-AAR-79-9 (Antilles Air Boats Inc. Grumman G21A St. Thomas V1 02 September 1978)

accessible, relatively low-cost option to life-preservers. The accident experience suggests that a better margin of safety would be provided in the event of a ditching or inadvertent water impact if passenger aircraft, regardless of size, were equipped with flotation seat cushions.

5.3.3 Infant Life-Jackets

Although there is a technical specification for infant life-jackets in TSO 13C, ANO Series II No. 8 does not provide for the carriage of infant-sized life-jackets in passenger-carrying aircraft. Some Canadian carriers do voluntarily equip their aircraft with a number of these; however, in the absence of a regulatory requirement to carry them, their availability in an emergency cannot be guaranteed. Although there is no evidence in the accident record of infants drowning because of a lack of proper life-jackets, infants do travel on commercial aircraft in sufficient numbers to warrant the provision of appropriate equipment.

6.0 CONCLUSIONS

6.1 Most land plane water-contact accidents in Canada involve small aircraft not engaged in overwater flight and which are therefore not required by regulations to carry life-jackets.

6.2 Approximately 50 per cent of ditchings in Canada involve single-engined land planes which elect to force land in water rather on the inhospitable surrounding terrain.

6.3 The probabilities of a single-engined and twin-engined aircraft being involved in a ditching accident are not significantly different.

6.4 Most water-contact accidents involving transport-category aircraft occur during the approach and landing, or the take-off phase of flight.

6.5 There is evidence of sufficient differences between fixed- and rotary-wing aircraft, both in terms of reliability and operating environment, to justify a requirement for separate overwater life-support equipment regulations.

6.6 The use of 50 nautical miles from shore as the determining factor in the carriage of life-jackets is inappropriate since virtually all the water contact accidents in Canada occurred within 50 nautical miles from shore.

6.7 Twenty-three per cent of all aviation fatalities in Canada involve either floatplanes or amphibious aircraft.

6.8 The regulation which addresses passenger briefings on overwater survival equipment does not specifically require such a briefing prior to take-off in a floatplane.

6.9 Since occupants of floatplanes rarely have time to retrieve and don life-jackets in the event of an upset on take-off or landing, the current regulations, both for the stowage and the wearing of life-jackets on floatplanes, are inadequate.

6.10 The carriage of infant-sized life-jackets when children are on board is not required by regulation.

6.11 There is no regulatory mechanism for ensuring that technological improvements in slide/life-rafts are incorporated into equipment on Canadian aircraft.

6.12 Flotation seat cushions can provide a relatively low-cost alternative or supplement to life-jackets which are currently only provided on transport-category aircraft.

7.0 SAFETY ACTION

7.1 Recommendations

7.1.1 Privately Operated Land Planes - Life-Jackets

This study has revealed several deficiencies regarding the carriage and use of life-saving equipment for aircraft operating over water. Industry practices have been principally directed by regulatory requirement; however, this study has concluded that the requirements do not necessarily address the circumstances actually encountered in accidents. In particular, the underlying regulatory basis for carrying on-board life-jackets, which is predicated on a specific flight distance from shore, is inappropriate.

The Canadian accident record clearly indicates that almost all water-contact accidents, regardless of aircraft size, occur close to shore. Furthermore, the use of the probability of failure of one engine as the criterion for carriage of life-preservers on twin-engined aircraft is not validated by the accident record. Recognizing, as the result of the ditching of a Britten-Norman Islander near Toronto Island in January 1987, that the lack of life-jackets on commercial aircraft during the critical phases of overwater flight constituted a serious safety deficiency, the Board earlier recommended that:

> The Department of Transport require the carriage of effective personal flotation devices on commercial aircraft that regularly fly over or near significant bodies of open water, including those aircraft whose arrival or departure paths are over open bodies of water.
>
> CASB 88-21

While this recommendation addresses commercial aircraft, privately operated aircraft are similarly vulnerable during arrival or departure over water. Accordingly, the Board recommends that:

> The Department of Transport advise private operators of the results of this study and encourage the carriage of life-jackets on all flights where a forced landing onto water is a possibility.
>
> CASB 88-24

7.1.2 Floatplanes and Amphibious Airplanes - Life-Jackets

7.1.2.1 Wearing of Life-Jackets

The large number of fatal accidents involving floatplanes and amphibious aircraft is continuing cause for concern. Because these aircraft usually operate in a less controlled and less forgiving environment than other segments of the aviation industry, it is essential that as much as possible be done prior to flight to ensure the survival of the occupants of such aircraft in the event of a water-contact accident. The Board believes that the non-availability of life-jackets contributes to the high fatality rate experienced during landing and take-off accidents in operations from water. Indeed, in a floatplane or amphibian, the best way to ensure this availability is to wear such equipment during the time of highest risk. Acknowledging the operational limitations of existing equipment, the Board recommends that:

> The Department of Transport evaluate existing personal flotation devices to determine their suitability for use in aircraft and, if necessary, sponsor the development of a personal flotation device suitable for routine wear, with a view to making the wearing of such a device mandatory in floatplanes and amphibians when taxiing, landing on, or taking off from water.
>
> CASB 88-25

7.1.2.2 Stowage of Life-Jackets

ANO Series II No. 8 requires that life-jackets be "easily accessible" to ensure their availability at short notice. However, the accident record shows that they are often not immediately available to seated passengers in float and amphibious aircraft because they are stowed in a central location, often in the rear of the aircraft. The Board therefore recommends that:

> The Department of Transport clarify regulations to ensure that life-jackets in float and amphibious aircraft are stowed in such a manner so as to be easily accessible to each passenger when seated.
>
> CASB 88-26

7.1.2.3 Safety Briefings

The concept of a pre-flight safety briefing is well understood by air carriers and is required by Air Navigation Orders for the commercial operations governed by them. However, the Board believes that such briefings in general aviation floatplane operations are frequently omitted. Furthermore, the wording in ANO Series II No. 8 does not specifically address float or amphibious aircraft. The Board therefore recommends that:

> The Department of Transport require that passengers on board all float and amphibious aircraft be briefed as to the location and operation of life-saving equipment prior to taking off from or landing on water.

CASB 88-27

7.1.3 Evacuation Slide/Life-Rafts

The approval of combination slide/life-rafts on wide-bodied aircraft in Canada is implicit in Transport Canada's acceptance of the operating manuals of these aircraft. Currently, however, Transport Canada has no means for ensuring that such equipment continues to be updated as the TSO is amended. The Board therefore recommends that:

> The Department of Transport introduce regulations governing the technical and maintenance standards of evacuation slide/life-raft combinations.

CASB 88-28

7.1.4 Flotation Seat Cushions - Commercial Aircraft

The effectiveness of flotation seat cushions as a supplement to life-preservers has been demonstrated on a number of occasions. While FAR 25 only requires their installation on aircraft not certificated for ditching or not required to carry life-preservers, most large transport aircraft are equipped with such cushions. There is no mention of this equipment in FAR 23, and aircraft certified under this rule normally do not have

them. Since occupants of small aircraft may not have life-jackets available during a ditching or inadvertent water impact, the CASB recommends that:

> The Department of Transport require that all seat cushions on passenger-carrying commercial aircraft be of an approved flotation type.

CASB 88-29

7.1.5 Helicopter Regulations

The Board feels that the apparent differing level of mechanical reliability of helicopters, coupled with the harshness of the offshore operating environment, warrants separate regulatory provisions for helicopters operating over water. It is acknowledged that Transport Canada has addressed these differences through the limitations in company Operating Certificates; however, the possibility does exist that the ad hoc nature of these provisions may allow inadequately equipped helicopters to be operated over water. The Board therefore recommends that:

> The Department of Transport develop and publish helicopter-specific regulations regarding the carriage and use of overwater life-support equipment.

CASB 88-30

7.2 Safety Concern

7.2.1 Infant-Sized Life-Jackets

The Board is concerned that the use of adult-sized life-jackets would be hazardous to infants in the event of a water-contact accident. Many airlines are carrying infant-sized life-jackets on board their aircraft, and such practices are encouraged. The absence of accident data precludes recommending regulatory changes at this time; however, the Board will continue to monitor this safety issue.

AERONAUTICS ACT

Life-Saving Equipment Order

ORDER RESPECTING LIFE-SAVING EQUIPMENT FOR AIRCRAFT OPERATING OVER WATER

AIR NAVIGATION ORDER, SERIES II, NO. 8

Short Title

1. This Order may be cited as the Life-Saving Equipment Order.

Application

2. This Order applies to the operation of all Canadian aircraft.

General

3. No person shall authorize or commence a flight during which an aircraft described in an item of column I of Schedule I may engage in the type of operation described in column II of that item, unless that aircraft carries the equipment specified in column III of that item.

Standards

4. (1) Every life raft required to be carried on board an aircraft pursuant to these Regulations shall meet or exceed the technical, manufacturing and performance standards of the United States Federal Aviation Administration Regulations (Technical Standards Orders C12C or c70; dated April 11, 1967).

(2) Every life jacket required to be carried on board an aircraft pursuant to these Regulations shall meet or exceed the technical, manufacturing and performance standards of the United States Federal Aviation Administration Regulations (Technical Standards Orders C13C; dated April 11, 1967).

(3) On or after May 1, 1987, in addition to the provisions of the United States Federal Aviation Administration Regulations (Technical Standards Orders C13C; dated April 11, 1967), an adult life jacket required to be carried on board an aircraft must be capable of providing a total

buoyancy of not less than 15.9 kg and its gas inflation system must provide a buoyancy of not less than 14.5 kg.

Stowing Equipment

5. (1) Subject to subsection 4(2), every life jacket required to be carried on board an aircraft pursuant to these Regulations shall be stowed in such a manner as to be easily accessible to the person for whose use it is intended.

(2) Where an aircraft crew includes a cabin attendant and where specified life jackets are intended for use by infants, the life jackets shall be stowed in such manner as to be easily accessible to the cabin attendant.

Informing Passengers

6. No person shall fly an aircraft en route over water where life-saving equipment is required to be carried on board an aircraft pursuant to these Regulations for the over water portion of the flight unless, prior to commencing the over water portion of the flight, all passengers are informed of the location and method of use of the life-saving equipment carried for their use.

Life Jacket Illumination

7. Effective January 1, 1984, every life jacket required to be carried on board an aircraft pursuant to these Regulations shall be equipped with a means of illumination for the purpose of facilitating the location of persons in water.

Maintaining Equipment

8. Every operator of an aircraft shall maintain all life-saving equipment required to be carried on board an aircraft in a serviceable condition in the manner recommended by the manufacturer of the life-saving equipment.

SCHEDULE I

(s. 3)

LIFE-SAVING EQUIPMENT REQUIREMENTS

Column I Aircraft	Column II Type of Operations	Column III Equipment Required on Board an Aircraft
Single-engined aircraft	1. (1) Operating beyond gliding distance from shore or taking off from or landing on water. (2) Operating more than 50 nautical miles from shore.	1. (1) One life jacket for each person on board. (2) The equipment specified in Schedule II in addition to the life jacket referred to in subsection (1).
Multi-engined aircraft unable to maintain flight with critical engine failed	2. (1) Operating beyond gliding distance from shore or taking off from or landing on water. (2) Operating more than 50 nautical miles from shore.	2. (1) One life jacket for each person on board. (2) The equipment specified in Schedule II in addition to the life jacket referred to in subsection (1).
Multi-engined aircraft able to maintain flight with critical engine failed	3. (1) Operating more than 50 nautical miles from shore or taking off from or landing on water. (2) Operating more than 300 nautical miles from shore.	3. (1) One life jacket for each person on board. (2) The equipment specified in Schedule II in addition to the life jacket referred to in subsection (1).
Turbo jet aircraft with three or more engines used on over water flights and with two engines inoperative are capable of continuing from any point along the route to an aerodrome suitable for landing	4. (1) Operating more than 50 nautical miles from shore or taking off from or landing on water. (2) Operating at a greater distance than can be covered in two hours at the cruising speed selected for the flight or 400 nautical miles, whichever is the lesser.	4. (1) One life jacket for each person on board. (2) The equipment specified in Schedule III in addition to the life jacket referred to in subsection (1).

SCHEDULE II

(s. 3)

EMERGENCY EQUIPMENT

1. Life rafts sufficient in total rated capacity to accommodate all persons on board an aircraft, stowed in such a manner as to be easily accessible for use in the event that the aircraft makes a ditching, fitted with

(a) water, or a means of desalting or distilling salt water, sufficient to provide at least one pint of water per person at the rated capacity of the life raft;

(b) a water bag;

(c) water purification tablets;

(d) food that

(i) is in the form of carbohydrate,

(ii) has a calorific value of at least 500 calories per person at the rated capacity of the life raft,

(iii) is not subject to deterioration by heat or cold;

(e) flares (at least three per raft);

(f) hole plugs;

(g) a bail bucket and sponge;

(h) a signal mirror;

(i) a whistle;

(j) a knife;

(k) a survival at sea manual;

(l) waterproof flash lights (minimum two per raft);

(m) a first aid kit containing eye ointment, burn ointment, compresses, bandages, methiolate and sea sick pills; and

(n) a dye marker.

2. The equipment required by paragraphs 1(a) and (d) may be stored and carried in appropriate containers separate from the rafts if the containers can be readily and quickly attached to the rafts.

SCHEDULE III

(s. 3)

EMERGENCY EQUIPMENT

1. Life rafts sufficient in total rated capacity to accommodate all persons on board an aircraft, stowed in such a manner as to be easily accessible for use in the event that the aircraft makes a ditching, fitted with

(a) a water bag;

(b) a water desalting kit (at least one per raft);

(c) flares (at least three per raft);

(d) hole plugs;

(e) a bail bucket and sponge;

(f) a signal mirror;

(g) a whistle;

(h) a knife;

(i) a survival at sea manual;

(j) waterproof flash lights (minimum two per raft);

(k) a first aid kit containing eye ointment, burn ointment, compresses, bandages, methiolate and sea sick pills; and

(l) a dye marker.